IMPROVED FACTORS IN GRADING COTTONSEED

Marketing Research Report No. 884

Agricultural Research Service
and
Consumer and Marketing Service
UNITED STATES DEPARTMENT OF AGRICULTURE

CONTENTS

	Page
Summary	1
History of the cottonseed processing industry	1
Early interest in grading cottonseed	2
Grading based on chemical analysis	3
Present grading system	3
Methods of chemical analysis	3
Quality Index	4
Quantity Index	4
Proposal for improving the Quantity Index	5
Determination of available yields of products	5
Derivation of oil, ammonia, and linters factors	6
Comparison of present and proposed factors	7
When grading factors should be changed	8
Sampling cottonseed	8
New sampling device	8
Tonnage represented by sample	9
Appendix	11

Washington, D. C. Issued April 1971

For sale by the Superintendent of Documents, U.S. Government Printing Office Washington, D.C. 20402 — Price 20 cents

IMPROVED FACTORS IN GRADING COTTONSEED

By MARION E. WHITTEN, *research chemist, Market Quality Research Division, Agricultural Research Service;* WILLIAM T. COLEMAN, *chief chemist, Paymaster Oil Mill Co.;* and R. T. DOUGHTIE, JR., *cottonseed technologist, Cotton Division, Consumer and Marketing Service*

SUMMARY

First efforts at grading cottonseed were made by the Interstate Cottonseed Crushers Association in 1889. Cottonseed was classified as "prime" and "off." The "cut and count" method, based on the number of immature and damaged seed, was adopted. Later methods were based on the moisture and foreign matter content and the number of immature and damaged seed and discolored kernels. Grades were based on personal opinion and discounts were frequently excessive. No provisions were made for the better-than-average seed.

Work on a new grading method was begun in 1935. In 1928 a method called "cake-oil reciprocal" had been developed. This method was based on the price relationship of oil and cake or meal. Losses due to excess free fatty acids were used as a quality index.

When the reciprocal method did not meet the needs of the cottonseed industry, the U.S. Department of Agriculture and the industry developed the present grading system, the Official Standard Grades for Cottonseed, which was established in June 1932. Basis grade cottonseed was set at 18.5 percent oil and 3.5 percent ammonia. For the Quality Index, prime cottonseed was prescribed as containing no more than 12 percent moisture, 1.8 percent free fatty acids, and 1 percent foreign matter. The Quantity Index was based on the price relationship of 1 pound of oil to 5 pounds of meal. Later, when the wide variation of linters content indicated the need, a linters factor was incorporated into the standards.

Means for relating the analysis of cottonseed to actual value is based upon actual outturns of products. Formulas have been derived to determine actual products available. Factors that represent oil, meal (ammonia × 235= pounds of 41 percent protein meal in a ton of seed), and linters are derived by substitution in formulas indicating the value of seed. These factors are rounded to the nearest half unit for simplicity of calculation. A comparison of the present 1 to 5 ratio formula with formulas derived by the proposed methods indicates that the proposed method improves the accuracy of all price relationships.

In 1932, a 25-ton lot of cottonseed was authorized as the largest lot to be represented by a single sample. A corkscrew-type probe was used to sample the load, or an unloading sample was taken. Later, in 1963, up to 60-ton lots received during a 3-day period were authorized as the largest lot to be represented by a single sample. In 1965, a pneumatic probe sampler replaced the corkscrew-type probe. In 1967, up to 100-ton lots were authorized, based upon a study that indicated this tonnage as the maximum amount to be represented by a sample.

HISTORY OF THE COTTONSEED PROCESSING INDUSTRY

Although cotton has been grown for several thousand years, the use of cottonseed as a commercial product is relatively new. The ancient Chinese and Hindus are said to have used crude methods for obtaining oil from cottonseed, using a form of mortar and pestle.[1] The oil was used as fuel in lamps and

[1] Bass, Lawrence W., and Alcott, H. S. A Chronology of Cottonseed Technology. News Edition. v. 18, No. 4. February 25, 1940.

the rest of the seed was fed to cattle. For centuries thereafter, the method of oil extraction was not improved and was confined to local areas.

Cotton was first grown in America in the colony of Virginia in 1607; however, no attempt was made to extract oil from cottonseed until the cotton gin was invented in 1793. The first screw press for extracting cottonseed oil was patented by a Mr. C. Whiting in 1799, but, unfortunately, it was not successful.[2] During the early 19th century, many efforts were made to process cottonseed. The first cottonseed oil mill was established in 1801. Oil mills were operating at Natchez, Miss., Florence, Ga., and Petersburg, Va., in 1834. These mills were not successful.

These early mills failed for several reasons. First, most American varieties of cotton are covered with linters, which are not removed at the gin. The early mills attempted to remove the oil by crushing the whole seed; however, the linters and the hulls absorbed much of the oil. Second, transportation difficulties contributed to the early oil mill problems. Poor and often impassible roads and lack of an adequate network of the then developing railroads added to mill problems. Water transportation was used to a great extent in the very early days.

Despite these problems, new mills were built. In 1860, seven mills were in operation. Although the fledgling industry did not grow during the war period from 1861 to 1865, new impetus was at hand. Machinery was developed that would remove linters and hulls from the seed kernels, and then the processing of cottonseed was economically feasible.

In 1870, there were 26 crushing mills in operation; in 1880, there were 45. In 1880, 27000 tons of cottonseed oil was produced from 182,000 tons of cottonseed. This production tonnage marked the attainment of industrial maturity by the industry.

In 1887, the first cottonseed testing laboratory was established by David Wesson for the American Cotton Oil Co. By 1900, a successful method of refining, bleaching, and deodorizing had been perfected, largely through the efforts of David Wesson, Thomas Eckstein, and James Boyce, working individually. The Society of Cotton Products Analysts was formed in 1910 and became the American Oil Chemists' Society in 1921.

The number of oil mills increased to about 975 in 1901; however, the number decreased and in 1968 only about 145 mills were in operation. The reduction in number was similar to that found in other agricultural industries. In earlier years, limited transportation favored a large number of small plants near the source of seed. In later years, inefficient operation of some mills, the highly competitive industry, and the shift in areas of cotton production contributed to reducing the number of mills. Even so, the capacity of existing mills is much greater than that of the early mills and the total capacity of the industry is about the same as it was in earlier years.

EARLY INTEREST IN GRADING COTTONSEED

In answer to a request by the cottonseed industry, first efforts to develop a system of grading cottonseed were made in 1895 by the U.S. Department of Agriculture. These early efforts were based upon a physical inspection of the seed. In 1889, the Interstate Cottonseed Crushers Association had adopted rules defining "prime" cottonseed and classifying all cottonseed not meeting "prime" requirements as "off" seed. Among the methods adopted was the "cut and count," which was based on the number of immature and damaged seed in a sample of 100 random-selected seed. An additional rule provided for reduction in grade if foreign matter content exceeded 1 percent. Later methods were based on moisture and foreign matter content, immature and damaged seed, and discolored kernels; but the accuracy of such determination was based almost entirely on personal opinion and discounts frequently were exces-

[2] Bailey, A. E., ed. Cottonseed and Cottonseed Products. 936 pp. New York. 1948.

sive. No provisions were made for better-than-average seed.

As the value of cottonseed increased, the need for an equitable system of grading became more apparent. With the new and better methods of analysis available, processors became aware of the wide variation in the amount of oil and meal available from different lots of seed. As a result, the industry again requested the U.S. Department of Agriculture to assist in developing a system of grading. In 1925, work on a new grading system was begun as a joint effort between the Department and industry.

GRADING BASED ON CHEMICAL ANALYSIS

In 1928, a forerunner of the present system of grading cottonseed was developed, largely through the efforts of Charles H. Cox, a cottonseed chemist. This system was based on the principle that the quantity and quality of the oil and of the cake or meal available from cottonseed should be the main determinants of seed value. Studies of product value indicated that this principle was the logical approach. Frequently, the value of 1 pound of oil was found to be equal to the value of 5 pounds of cake or meal. A method was developed to convert total oil and meal values into an oil equivalent; this table was called the "oil-cake reciprocal." According to data available at the time, cottonseed contained about 19 percent oil and 3.70 percent ammonia, indicating the presence of 380 pounds of oil and 875 pounds of 41.13 percent protein meal in a ton of seed.

With meal one-fifth as valuable as oil, the total "equivalent" in the average seed was 380 plus 175 (875 divided by 5 equals 175) or a total of 555 pounds. This 555-pound unit served as a quantity index of 100. By using this method, the Quantity Index could then be calculated from the analysis of any lot of seed.

Another table was developed with respect to losses due to free fatty acids as the Quality Index of cottonseed. This table was combined with the Quantity Index to derive a table of relative values. The losses due to free fatty acids were reduced to a simple formula using 1.8 percent free fatty acids as the average breaking point between prime and off-quality oils.

PRESENT GRADING SYSTEM

When it was apparent that the "reciprocal" method established by the industry would not meet necessary requirements, work was continued on other methods for analyzing and grading cottonseed. The present grading system was the result of these efforts and the Official Standard Grades for Cottonseed were established in June 1932. A 100 grade cottonseed was established as the Basis Grade Cottonseed. A press release dated June 6, 1932, stated: "From one ton of cottonseed of this grade (100), an efficient cottonseed oil mill should be able to obtain 313 pounds of oil, 822 pounds of meal (41.13 percent), 125 pounds of linters and 640 pounds of hulls." This 100 grade basis seed was established as that containing 18.5 percent oil and 3.5 percent ammonia.

Methods of Chemical Analysis

Both a reliable method of chemical analysis and uniformity of procedure were necessary requisites for a workable grading program. Investigations by Malowan [3] and Cox [4] solved the problem of preparing an acceptable laboratory sample. Work by a committee of the American Oil Chemists' Society [5] resulted in the development of a reliable method for free fatty acids assay. Studies of methods of analy-

[3] Malowan, John. Report of Damaged Seed Committee. Cotton Gin and Oil Mill Press 4(3): 77. 1920.

[4] Cox, C. H. A Method for the Analysis of Cottonseed. Oil and Fat Indus. Jour. 3: 125–127. 1962.

[5] Brodie, R. H., chairman. Report of the Committee on Determination of Free Fatty Acids of Oil in Seed, American Oil Chemists' Society. Oil and Fat Indus. Jour. 4: 177–181. 1927.

sis were made by the U.S. Department of Agriculture-Industry Committee (particularly G. S. Meloy and G. S. Jamieson for the Department and C. H. Cox and A. S. Richardson for Industry), and from these, chemical procedures were selected and published as an integral part of the grading system.

Quality Index

The grade of cottonseed is now divided into two parts, the Quality Index that is generally related to those elements associated with quality of the products and the Quantity Index that reflects the value of the quantity of the products that can be obtained from the cottonseed. The Quality Index is 100 when the chemical analysis indicates that prime products can be made from the cottonseed. When the chemical analysis indicates production of lower quality products or difficulty in cleaning or storage of the cottonseed, the Quality Index reflects this situation.

Discounts for Foreign Matter

Years ago the industry established a trading rule requiring the deduction of the weight of foreign matter from the gross weight of cottonseed to discourage the practice of incorporating foreign matter with seed at gins. Because foreign matter stimulates deterioration [6] and is difficult and costly to remove, foreign matter must also be included as an element of grade. The present standards require a discount of 0.1 unit in the Quality Index for each 0.1 percent foreign matter in excess of 1.0 percent.

Moisture Factor

Moisture content is the primary cause of deterioration in cottonseed. Prime cottonseed of low moisture content may be stored for well over a year and yield prime products. Excess moisture in seed may cause rapid deterioration. A moisture content of 12 percent was established as the critical point in the storage of cottonseed beyond which cooling or drying is necessary to preserve quality. To offset cooling or drying expense necessitated by excess moisture content, the present standards require a discount of 0.1 unit in the Quality Index for each 0.1 percent moisture in excess of 12.0 percent.

Free Fatty Acids Factor

Cottonseed produced under favorable weather conditions usually contain from 10 to 12 percent moisture and from 0.5 to 1.0 percent free fatty acids. Data on which the standards were based indicated that cottonseed with 1.8 percent or less free fatty acids would produce prime products. To compensate for loss in product value because of excess free fatty acids, the present standards require a discount of 0.4 unit in the Quality Index for each 0.1 percent free fatty acids in excess of 1.8 percent.

Quantity Index

The Quantity Index was established to reflect the value of the quantity of products available. The three factors used to determine the Quantity Index are the oil and linters factors that reflect the value of the oil and linters and the ammonia factor that reflects the relative value accounted for by the meal available in the seed.

Derivation of Oil and Ammonia Factors

As previously mentioned, price studies revealed that the value of 1 pound of crude cottonseed oil was equivalent to as much as 6 and as little as 4 pounds of cottonseed meal (41 percent protein). An oil to meal ratio of 1 to 5 occurred most frequently and that ratio was selected as the basis of the Quantitiy Index. When the values of products obtained from cottonseed were plotted against the oil-ammonia reciprocal, scientists found that the following simple formula would fit this relationship: [7] The oil content times 4 plus the ammonia content times 5 plus a constant of 5. This formula was therefore selected for use in calculating the Quantity Index.

[6] Alderks, O. H. *In* Bailey, A. E., ed. Cottonseed and Cottonseed Products. pp. 567–587. New York. 1948.

[7] Richardson, A. S. Private communication.

Need for Linters Factor

Because the value of linters, as compared with that of oil and meal, was quite low, the need for a linters factor in grading was not considered important when the standards were developed. Nor was an adequate method of analysis for linters available. After the standards were made official by the U.S. Department of Agriculture the necessity of the linters factor became more apparent in those areas where the residual linters content on seed was extremely high or low. In high linters content areas, the exclusion of linters was inequitable to the ginner. In low linters content areas, the exclusion was inequitable to the oil miller. In one area of low linters content, west Texas, a linters factor was used on a trial basis for several years. Then in 1954, the linters factor was officially made part of the grading system. This factor is based on the difference in value of a ton of basis 100 grade cottonseed when the linters content varies by 20 pounds, but the oil and ammonia content remains constant. In other words, the linters factor is the percentage change in value of a ton of cottonseed when the linters content increases 20 pounds, the hull content decreases 20 pounds, and all other factors remain constant.

As the linters content of cottonseed decreases below the average (10.5 percent), the discount factor increases in increments because the shorter fibers are less valuable and the cost per pound of removing the linters is greater.[8]

PROPOSAL FOR IMPROVING THE QUANTITY INDEX

A prime requisite for a successful grading system for cottonseed is simplicity of operation. The present method of determining the Quantity Index meets this requisite. However, inequities become more and more apparent as the oil to meal price relationship moves from the 1 to 5 ratio mentioned earlier. A proposal made by Coleman in 1952 [9] more nearly approached an "ideal" grading system. Unfortunately, the method is too involved for practical use. However, formulas have been derived, which can be used to determine more accurate factors for oil and ammonia.

Determination of Available Yields of Products

A means for accurately relating the analysis of cottonseed to the actual outturn of products is necessary in the development of any grading system. Also, the determination of available yields of products must be based on a materials balance, which depends upon the efficiency of the milling process.

The amount of oil available from a ton of cottonseed can be determined by subtracting the oil remaining in meal, hulls, and linters from the total oil in the seed as determined by chemical analysis. An average of about 3 percent oil is left in the meal with the present milling practices. In the Midsouth where considerably more data on seed are available, the average oil left in the meal was 2.8 percent for the 3-year period 1965–67. It is assumed that 7 pounds of oil remains in the linters and hulls.

The meal yield in pounds per ton is:

$$\frac{2{,}000 \times \%\text{ ammonia in seed} \times \%\text{ ammonia recovery}}{\%\text{ ammonia in meal} \times 100}$$

For 8 percent ammonia meal and with 94-percent recovery, the meal yield in pounds per ton

$$= \frac{2{,}000}{8} \times \frac{94}{100} \times \%\text{ ammonia in seed}$$

$$= 250 \times 0.94 \times \%\text{ ammonia in seed}$$

$$= 235 \times \%\text{ ammonia in seed}$$

The total oil in seed in pounds per ton

$$= 2{,}000 \times \frac{\%\text{ oil in seed}}{100}$$

$$= 20 \times \%\text{ oil in seed}$$

[8] Standards for Grades of Cottonseed Sold or Offered for Sale for Crushing Purpose Within the United States. U.S. Department of Agriculture, Consumer and Marketing Service, Service and Regulatory Announcement 179. Revised May 1966.

[9] Coleman, W. T. Private communication. March 1952.

The oil left in cake or meal in pounds per ton
$= 235 \times$ % ammonia in seed
$$\times \frac{\text{\% oil in cake or meal}}{100}$$

The oil lost in meal in pounds per ton

$$= 235 \times \frac{3}{100} \times \text{\% ammonia in seed}$$

$= 7.05 \times$ % ammonia in seed

With the oil lost in hulls and linters assumed at a constant of 7 pounds per ton of seed:

The oil yield in pounds per ton of seed
$= (20 \times$ % oil in seed)
$- (7.05 \times$ % ammonia$) - 7$

Individual oil mills remove varying amounts of linters from cottonseed, depending upon market conditions and other circumstances. However, in this study we will assume that an average of 50 pounds of linters are left on the seed. The total linters removed by the mills from a lot of seed may be expressed as follows:

Pounds of linters removed
$= 20 \times$ % linters on seed $- 50$

The manufacturing loss encountered in processing cottonseed depends upon the amount of foreign matter removed and the seed moisture lost during processing. This loss varies from year to year but on the average, about 125 pounds per ton of seed is lost. This amount will be used in this discussion.

The yield of hulls may be found by subtracting the oil, cake, linters, and manufacturing loss from 2,000, the weight of a ton of seed. Substituting the formulas derived above, we find:

The yield of hulls
$= 2{,}000 - (20 \times$ % oil$) - (7.05 \times$ % ammonia$)$
$- (235 \times$ % ammonia$)$
$- (20 \times$ % linters $- 50) - 125$

This may be further simplified to:
$1{,}933 - (20 \times$ % oil$)$
$- (227.95 \times$ % ammonia$)$
$- (20 \times$ % linters$)$

From the formulas just mentioned, and with a basis grade 100 cottonseed with 18.5 percent oil, 3.5 percent ammonia, and 10.5 percent linters, expected yields are:

	Pounds
Oil	338
Meal	822
Linters	160
Hulls	555
Mfg. Loss	125

Derivation of Oil, Ammonia, and Linters Factors

The value of a ton of cottonseed may be determined as the value of the products produced minus necessary costs to cover processing, transportation, and other expenses. In more precise terms, the value of seed may be expressed as follows: the value of a ton of seed equals the price of oil in cents per pound times the yield of oil plus the price of meal in cents per pound times the yield of meal plus the price of linters in cents per pound times the yield of linters plus the price of hulls in cents per pound times the yield of hulls minus a spread to cover production, transportation, and other costs.

Expressed as a formula, it is:
(price of oil in ¢/lb. $\times$ lb. oil)
+ (price of meal in ¢/lb. $\times$ lb. meal)
+ (price of linters in ¢/lb. $\times$ lb. linters)
+ (price of hulls in ¢/lb. $\times$ lb. hulls)
$-$spread

Substituting in the above formulas with formulas previously derived we have: Seed value
$=$ [price of oil $\times$ (20 $\times$ % oil)
$-$ (% ammonia $\times$ 7.05) -7] + [price of meal
$\times$ (235 $\times$ % ammonia)] + [price of linters
$\times$ (20 $\times$ % linters) -50] + [price of hulls
$\times$ (1,933 $-$ [20 $\times$ % oil])
$-$ (227.5 $\times$ % ammonia)
$-$ (20 $\times$ % linters)] $-$spread

Since the cost of seed
$$= \frac{\text{price of basis seed} \times \text{grade}}{100}$$
and the price of seed per ton
$=$ price of seed per pound $\times$ 2,000,
we can determine that the grade (Quantity Index) is equal to:

$$\frac{\text{price of oil} - \text{price of hulls}}{\text{price of seed}} \times \text{\% oil in seed plus}$$
$$\frac{(\text{price of meal} \times 235) - (\text{price of oil} \times 7.05) - (\text{price of hulls} \times 227.5)}{20 \times \text{price of seed}}$$

$$\times \%\text{ ammonia plus } \frac{\text{price of linters} - \text{price of hulls}}{\text{price of seed}} \times \%\text{ linters plus a constant.}$$[10]

The oil, ammonia, and linters factors and the formula constant may now be determined when the prices of oil, meal, hulls, linters, and seed are known. The following prices will be assumed:

	Cents per pound
Oil	12
Meal	4
Linters	4
Seed	3.2
Hulls	1

Using the formula derived on page 6, we find that the grade is:

$$\left[\frac{12-1}{3.2} \times 18.5\right] + \left[\frac{(4\times235) - (12\times7.05) - (1\times227.95)}{20\times3.2} \times 3.5\right] + \left[\frac{4-11}{3.2} \times 10.5\right] + \text{constant.}$$

This may be simplified to:

Oil Factor *Ammonia Factor* *Linters Factor*

$$(3.437\times18.5) + (9.804\times3.5) + (0.94\times10.5) + \text{constant} = 100$$

When the factors are rounded off to the nearest half unit for simplicity of operation, the equation will be:

Quantity Index

$$= (3.5\times18.5) + (10\times3.50) + (1\times10.5) - 10.75$$

If the linters factor is to be excluded, the formula will be:

Quantity Index

$$= (3.5\times18.5) + (10\times3.50) - 0.25$$

The correct factors for these prices would be:

Oil	3.5
Ammonia	10
Linters	1

The above formula allows for the determination of all three, which determine the Quantity Index.

$$\text{The oil factor} = \frac{\text{price of oil} - \text{price of hulls}}{\text{price of seed}}$$

The ammonia factor

$$= \frac{(235\times\text{price of meal}) - (7.05\times\text{price of oil}) - (227.95\times\text{price of hulls})}{20\times\text{price of seed}}$$

This may be further reduced to:

$$\frac{(11.75\times\text{price of meal}) - (0.352\times\text{price of oil}) - (11.397\times\text{price of hulls})}{\text{price of seed}}$$

The linters factor

$$= \frac{\text{price of linters} - \text{price of hulls}}{\text{price of seed}}$$

In the preceding explanation, a formula for the grade determination, including linters, is given. However, it is best that the linters value be calculated separately because the discount value for linters below 9.5 percent increases in increments to offset lowest linters value and increased cost in removing linters.[11]

Comparison of Present and Proposed Factors

Because for practical purposes it is expedient to express the calculated oil, ammonia, and linters factors to the nearest half unit, a comparison of the accuracy of grades determined using the present factors and proposed factors was made. First, predicted yields of products from cottonseed with specified oil and ammonia contents were calculated (appendix table 1). Using these data, the total product values for cottonseed at specific prices were determined. Values at specified oil and ammonia contents using the present and proposed oil and ammonia factors were determined for a range of oil and meal prices (other prices and values remaining constant).

When oil was priced at 12½ cents per pound and meal at 2½ cents, the ratio value was 5 to 1. The greatest error at specified oil and ammonia contents was 67 cents per ton when the present grading factors were used, compared with 43 cents when the proposed factors were used (appendix table 2).

When oil was priced at 10 cents per pound and meal at 4 cents, the ratio value was 2½ to 1. The greatest error at specified oil and ammonia contents was $3.59 per ton when the present grading factors were used, compared with 19 cents when the proposed factors were used (appendix table 3).

[10] The remaining factors in the above formula have been lumped into a constant.

[11] See footnote 8, p. 5.

Comparisons were then made using other price relationships. These are shown in appendix tables 3, 4, 5, 6, 7, and 8. In every instance, a greater error was found when the present factors were used. The proposed optimum factors result in a more accurate system of grading cottonseed.

When Grading Factors Should Be Changed

At present (1970), the Cotton Division Consumer and Marketing Service, U.S. Department of Agriculture, obtains prices of cottonseed products monthly from the southeastern, south central, southwestern, and far western areas of cotton production. These prices are used to determine the accuracy of the linters factor in cottonseed grading. They can also be used to evaluate the accuracy of the oil and ammonia factors.

Initially it would be necessary to establish a Department-industry committee to determine the minimum changes in grade factors as reflected by prices that would indicated the need for a change in the factors. When product prices indicate the need, such a change would then be made as required by Government regulations.

Frequent changes in grade factors would not be advisable under normal circumstances. Ordinarily, changes in factors would be made before processing new crop seed in the fall of the year. Only under unusual circumstances should factor changes be considered at any other time.

SAMPLING COTTONSEED

When the grading standards were made known in 1932, a large part of the cottonseed crop was shipped from gin to oil mill by rail. The rest of the crop was usually shipped by truck or wagon. The amount of cottonseed shipped in one railcar, about 25 tons, was selected as the amount of cottonseed that would be represented by a sample. These carlot samples varied considerably in composition because they were made up of individual bale lots varying in moisture content as well as in the quantity and quality of oil, protein, fiber, and hulls available. This variation was due to such conditions as seed variety, soil, and climate. The seed lots contained a variety of foreign materials such as sand, dirt, leaves, sticks, stones, and pieces of metal. In 1932 "one variety" communities were unheard of. Many varieties of cotton were planted in a locality, thus seed quality varied greatly from bale to bale.

Before the cottonseed grading standards were put into effect, samples had often been obtained by scooping seed in several locations from the top of the load. Under the new system, samples were obtained at several places within the load of seed with a helical or corkscrew-type probe or a sample was obtained at frequent intervals during unloading.

Later it was found that it was impossible for the person taking the sample to get into fully loaded railcars to take samples with the corkscrew-type probe and often the probe would not reach to the bottom of the car.

Bulk samples were often assembled in burlap bags and were therefore susceptible to atmospheric moisture and temperature changes. This was corrected by the use of large metallic containers with close-fitting covers.

A small shaker-cleaner, patterned after cleaning equipment used in the mills, was designed to separate foreign material from the gross sample and to select the small part to be held for chemical analysis. The cleaned seed and foreign material were weighed to determine the foreign material in the lot of seed. The small sample was placed in a friction-top can for chemical analysis. Multilayer paper bags were later used to hold the laboratory samples; however, these have now been replaced by plastic bags.

New Sampling Device

With the advent of large truck shipments of cottonseed from gin to oil mill, the use of the corkscrew-type probe became questionable. Considerable effort was required to force the probe into the mass of seed. Even after the probe was mechanized to expedite sampling,

difficulty was experienced in removing it from the load of seed. Too often the probe did not reach the bottom of the load. Further difficulty was caused by chains inside the load of seed, often fastened to both sides of the truck. When the tip of the mechanized probe being driven into the load hit the chain, muscles were often wrenched or the operator actually was sometimes thrown from the truck.

A pneumatic probe was later developed, which is easily probed into cottonseed and reaches the floor of the truck with little difficulty. A study of the efficiency of this sampling device was made jointly by the U.S. Department of Agriculture and the American Oil Chemists' Society, with cooperation of the industry at several locations in 1963. After several modifications were made, the pneumatic probe sampler performed satisfactorily. The new sampler, now official, was found to be equally accurate as the corkscrew-type probe, to require much less effort, to sample cottonseed in one-fourth the previous time, and to remove the possibility of serious accidents.

Tonnage Represented by Sample

As stated earlier, a 25-ton lot of cottonseed, received within 3 consecutive days, was authorized initially as the maximum amount of cottonseed that could be represented by a single sample. If no more than 10 tons but fewer than 25 tons were received within 6 consecutive days, a sample must be secured from this lot.

As the method of shipment from gin to oil mill changed, attention was directed to increasing the size of a lot of cottonseed that could be represented by a sample. Faster output at gins and newer varieties of cotton that matured at about the same time contributed to the receipt of much larger quantities of seed at the oil mill during a relatively shorter harvesting season.

The maximum tonnage allowed per sample was increased several times. Finally, in 1963, a 60-ton maximum was authorized.

A period of 3 consecutive days for collecting the gross sample was established to insure that the sample represented the lot of seed. Over longer periods, the sample may change from moisture loss or gain, especially if the seed are subject to deterioration because of high free fatty acids and moisture or any other cause.

With the increased pace in the harvesting of cotton whereby practically the entire crop is ginned in a 6- to 8-week period, large quantities of cotton are ginned each day. Because of the change in harvesting practices, it was apparent that a study should be made of the amount of cottonseed that could be represented by one sample. Under present marketing practices, often six bale lots of seed cotton are delivered to the gin on a large truck compared with one bale lot in earlier years.

A study was made by the U.S. Department of Agriculture [12] and the industry to determine the optimum size of a lot of cottonseed that can be represented by a sample. Four oil mills, representing different regions of the Cotton Belt, cooperated by sampling early, midseason, and late-season cottonseed received from four randomly selected gins. In the study, probes were made at four random locations in each lot of cottonseed. From seed obtained from each individual probe, two 1-pound subsamples were prepared from opposite quarters of each probe. The remainder of the seed were made into another sample.

Results of the study indicated the following: Within a gross lot of 100 tons of cottonseed, a sample can be obtained from 10 random probes, which will result within three grade point values of the true grade of the cottonseed 95 percent of the time. Additional probes would not materially increases the accuracy. On the other hand, an average of the analyses of two samples from the gross sample would increase the accuracy of the results by more than 25 percent.

Because 10 random probes appeared to be satisfactory for a 100–ton lot of cottonseed, it becomes necessary to divide these probes among trucks making up the 100 tons. Because the average large truck moves approximately 20 to 25 tons and the small trucks, 10 to 12 tons, it

[12] Statistical Staff and Cotton Division, Consumer and Marketing Service, and Market Quality Research Division, Agricultural Research Service.

will be necessary to randomly probe the large trucks twice and the small trucks once to obtain 10 probes for each gross 100-ton lot. Only one-half pound of seed per ton is obtained for the gross sample by this procedure.

Probe cards were prepared, on which the trucks were divided into equal areas. The probe positions were randomly selected. A series of 40 cards was prepared (fig. 1). The sampler could shuffle the cards or otherwise randomly select a card. He would then probe positions 1 and 2 for large trucks or position 1 for small trucks. Additional probes may alter the results unless a proportionately greater number of probes are taken from each truck represented in the 100-ton lot of seed.

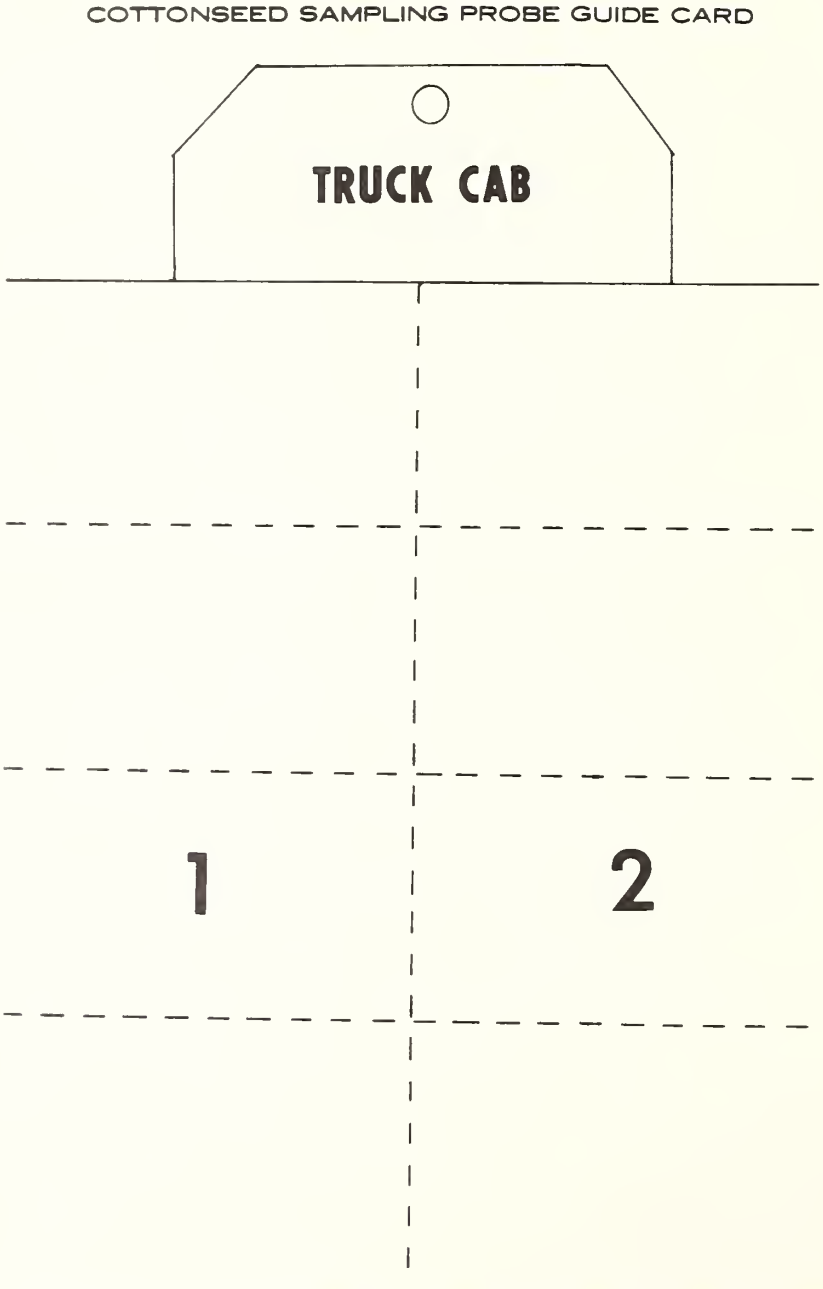

FIGURE 1.—Facsimile of a U.S. Department of Agriculture cottonseed sampling probe guide card.

APPENDIX

TABLE 1.—*Predicted yields (pounds per ton) of products from cottonseed with specified oil and and ammonia contents* [1] [2]

Content	Predicted yield of [3] — Oil	Meal	Hulls
16% oil and —			
3.50% ammonia	288	822	605
3.75% ammonia	287	881	547
4.00% ammonia	285	940	490
4.25% ammonia	283	999	433
16.5% oil and —			
3.50% ammonia	298	822	595
3.75% ammonia	297	881	537
4.00% ammonia	295	940	480
4.25% ammonia	293	999	423
17% oil and —			
3.50% ammonia	308	822	585
3.75% ammonia	307	881	527
4.00% ammonia	305	940	470
4.25% ammonia	303	999	413
17.5% oil and —			
3.50% ammonia	318	822	575
3.75% ammonia	317	881	517
4.00% ammonia	315	940	460
4.25% ammonia	313	999	403
18% oil and —			
3.50% ammonia	328	822	565
3.75% ammonia	327	881	507
4.00% ammonia	325	940	450
4.25% ammonia	323	999	393
18.5% oil and —			
3.50% ammonia	338	822	555
3.75% ammonia	337	881	497
4.00% ammonia	335	940	440
4.25% ammonia	333	999	383
19% oil and —			
3.50% ammonia	348	822	545
3.75% ammonia	347	881	487
4.00% ammonia	345	940	430
4.25% ammonia	343	999	378
19.5% oil and —			
3.50% ammonia	358	822	535
3.75% ammonia	357	881	477
4.00% ammonia	355	940	420
4.25% ammonia	353	999	363
20% oil and —			
3.50% ammonia	368	822	525
3.75% ammonia	367	881	467
4.00% ammonia	365	940	410
4.25% ammonia	363	999	353
20.5% oil and—			
3.50% ammonia	378	822	515
3.75% ammonia	377	881	457
4.00% ammonia	375	940	400
4.25% ammonia	373	999	343
21% oil and —			
3.50% ammonia	388	822	505
3.75% ammonia	387	881	447
4.00% ammonia	385	940	390
4.25% ammonia	383	999	333
21.5% oil and —			
3.50% ammonia	398	822	495
3.75% ammonia	397	881	437
4.00% ammonia	395	940	380
4.25% ammonia	393	999	323

[1] Basis 3 percent oil left in meal; 7 pounds of oil left in hulls and linters; 50 pounds of linters remaining on delinted seed.

[2] Average manufacturing loss is 125 pounds per ton of seed.

[3] Predicted yield of linters is 160 pounds per ton of seed.

TABLE 2.—*Total value of products obtained from cottonseed of specified composition and at specified prices, the Quantity Index, the proposed Quantity Index, and error when these Quantity Indexes are used* [1]

Content	Total product value	Value present grade	Error	Value proposed grade	Error	Present Quantity Index	Proposed Quantity Index
	$/ton	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*Units*	*Units*
16% oil and—							
3.50% ammonia	69.00	49.28	−0.28	49.28	−0.28	90.0	90.00
3.75% ammonia	69.77	50.10	− .33	50.00	− .23	91.5	91.25
4.00% ammonia	70.43	50.92	− .49	50.65	− .23	93.0	92.50
4.25% ammonia	71.07	51.74	− .67	51.33	− .26	94.5	93.75
16.5% oil and—							
3.50% ammonia	70.15	50.37	− .22	50.37	− .22	92.0	92.0
3.75% ammonia	70.92	51.19	− .27	51.05	− .13	93.5	93.25
4.00% ammonia	71.57	52.01	− .44	51.74	− .20	95.0	94.5
4.25% ammonia	72.22	52.83	− .61	52.42	− .20	96.5	95.75
17% oil and—							
3.50% ammonia	71.30	51.46	− .16	51.46	− .16	94.0	94.0
3.75% ammonia	72.07	52.29	− .22	52.15	− .08	95.5	95.25
4.00% ammonia	72.73	53.11	− .38	52.83	− .10	97.0	96.5
4.25% ammonia	73.37	53.93	− .56	53.52	− .15	98.5	97.75
17.5% oil and—							
3.50% ammonia	72.45	52.56	− .11	52.56	− .11	96.0	96.0
3.75% ammonia	73.23	53.38	− .15	53.24	− .01	97.5	97.25
4.00% ammonia	73.87	54.20	− .33	53.93	− .06	99.0	98.5
4.25% ammonia	74.53	55.02	− .49	54.61	− .08	100.5	99.75
18% oil and—							
3.50% ammonia	73.60	53.65	− .05	53.65	− .05	98.0	98.0
3.75% ammonia	74.34	54.48	− .14	54.34	0	99.5	99.25
4.00% ammonia	75.03	55.30	− .27	55.02	+ .01	101.0	100.5
4.25% ammonia	75.67	56.12	− .45	55.71	− .04	102.5	101.75
18.5% oil and—							
3.50% ammonia	74.75	54.75	0	54.75	0	100.0	100.0
3.75% ammonia	75.53	55.57	− .04	55.43	− .10	101.5	101.25
4.00% ammonia	76.17	56.39	− .22	56.12	+ .05	103.0	102.50
4.25% ammonia	76.87	57.21	− .34	56.80	+ .07	104.5	103.75
19% oil and—							
3.50% ammonia	75.90	55.84	+0.06	55.84	+0.06	102.0	102.0
3.75% ammonia	76.67	56.67	0	56.53	+ .14	103.5	103.25
4.00% ammonia	77.33	57.49	− .16	57.21	+ .12	105.0	104.5
4.25% ammonia	78.02	58.31	− .29	57.90	+ .12	106.5	105.75
19.5% oil and—							
3.50% ammonia	77.05	56.94	+ .11	56.94	+ .11	104.0	104.0
3.75% ammonia	77.83	57.76	+ .07	57.62	+ .21	105.5	105.25
4.00% ammonia	74.84	58.58	− .10	58.31	+ .17	107.0	106.5
4.25% ammonia	79.13	59.40	− .23	59.00	+ .13	108.5	107.75
20% oil and—							
3.50% ammonia	78.20	58.04	+ .16	58.04	+ .16	106.0	106.0
3.75% ammonia	78.97	58.86	+ .11	58.72	+ .25	107.5	107.25
4.00% ammonia	59.62	59.68	− .06	59.40	+ .22	109.0	108.5
4.25% ammonia	80.27	60.50	− .23	60.09	+ .21	110.5	109.75

See footnote at end of table.

TABLE 2.—*Total value of products obtained from cottonseed of specified composition and at specified prices, the Quantity Index, the proposed Quantity Index, and error when these Quantity Indexes are used*[1]—Continued

Content	Total product value	Value present grade	Error	Value proposed grade	Error	Present Quantity Index	Proposed Quantity Index
	$/ton	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*Units*	*Units*
20.5% oil and—							
3.50% ammonia	79.35	59.13	+ .23	59.13	+ .23	108.0	108.0
3.75% ammonia	80.13	59.95	+ .18	59.18	+ .22	109.5	109.25
4.00% ammonia	80.77	60.77	0	60.50	+ .27	111.0	110.5
4.25% ammonia	81.43	61.59	− .16	61.18	+ .25	112.5	111.75
21.0% oil and—							
3.50% ammonia	80.50	60.23	+ .27	60.23	+ .27	110.0	110.0
3.75% ammonia	81.27	61.05	+ .22	60.90	+ .37	111.5	111.25
4.00% ammonia	81.93	61.87	+ .06	61.59	+ .34	113.0	112.5
4.25% ammonia	82.59	62.89	− .32	62.28	+ .19	114.5	113.75
21.5% oil and—							
3.50% ammonia	81.65	61.32	+ .33	61.32	+ .33	112.0	112.0
3.75% ammonia	82.43	62.14	+ .29	62.00	+ .43	113.5	113.25
4.00% ammonia	83.07	82.96	+ .11	62.69	+ .38	115.0	114.5
4.25% ammonia	83.73	63.78	− .05	63.37	+ .36	116.5	115.75

[1] Prices: oil, 12½¢/lb.; meal, $50/ton; linters, 4¢/lb; hulls, $20/ton; seed, $54.75/ton. Basis grade 100: 18.5% oil, 3.50% ammonia. Spread $20. Proposed Quantity Index: (oil × 4.5) + (ammonia × 5) + 8.5.

TABLE 3.—*Total value of products obtained from cottonseed of specified composition and at specified prices, the Quantity Index, the proposed Quantity Index, and error when these Quantity Indexes are used* [1]

Content	Total product value	Value present grade	Error	Value proposed grade	Error	Present Quantity Index	Proposed Quantity Index
	$/ton	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*Units*	*Units*
16% oil and—							
3.50% ammonia	74.13	52.77	+1.36	54.23	−0.10	90.0	92.50
3.75% ammonia	75.81	53.65	+2.16	55.85	− .04	91.5	95.25
4.00% ammonia	77.40	54.53	+2.87	57.45	− .05	93.0	98.0
4.25% ammonia	78.99	55.40	+3.59	59.07	− .08	94.5	100.75
16.5% oil and—							
3.50% ammonia	75.03	53.94	+1.09	55.11	− .08	92.0	94.0
3.75% ammonia	76.71	54.82	+1.89	56.72	− .01	93.5	96.75
4.00% ammonia	78.30	55.70	+2.60	58.34	− .04	95.0	99.5
4.25% ammonia	79.89	56.58	+3.31	59.95	− .06	96.5	102.25
17% oil and—							
3.50% ammonia	75.93	55.11	+ .82	55.99	− .06	94.0	95.5
3.75% ammonia	77.61	55.99	+1.62	57.60	− .01	95.5	98.25
4.00% ammonia	79.20	56.87	+2.33	59.22	− .02	97.0	101.0
4.25% ammonia	80.79	57.75	+3.04	60.83	− .04	98.5	103.75

See footnote at end of table.

TABLE 3.—*Total value of products obtained from cottonseed of specified composition and at specified prices, the Quantity Index, the proposed Quantity Index, and error when these Quantity Indexes are used* [1]—Continued

Content	Total product value	Value present grade	Error	Value proposed grade	Error	Present Quantity Index	Proposed Quantity Index
	$/ton	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*Units*	*Units*
17.5% oil and—							
3.50% ammonia	76.83	56.82	+ .55	56.87	− .04	96.0	97.0
3.75% ammonia	78.51	57.16	+1.35	58.48	+ .03	97.5	99.75
4.00% ammonia	80.10	58.04	+2.06	60.10	0	99.0	102.5
4.25% ammonia	81.69	58.92	+2.77	61.71	− .02	100.0	105.25
18% oil and—							
3.50% ammonia	77.73	57.46	+ .27	57.75	− .02	98.0	98.5
3.75% ammonia	79.41	58.43	+1.07	59.36	+ .05	99.5	101.25
4.00% ammonia	81.00	59.22	+1.78	60.97	+ .03	101.0	104.0
4.25% ammonia	82.59	60.10	+2.49	62.59	0	102.5	106.75
18.5% oil and—							
3.50% ammonia	78.63	58.63	0	58.63	0	100.0	100.0
3.75% ammonia	80.31	59.51	+ .80	60.24	+ .07	101.5	102.75
4.00% ammonia	81.90	60.39	+1.51	61.85	+ .05	103.0	105.5
4.25% ammonia	83.49	61.27	+2.22	63.47	+ .02	104.5	108.25
19% oil and—							
3.50% ammonia	79.53	59.80	−0.27	59.51	+0.02	102.0	101.50
3.75% ammonia	81.21	60.68	+ .53	61.22	− .01	103.5	104.25
4.00% ammonia	82.80	61.56	+1.24	62.73	+ .07	105.0	107.0
4.25% ammonia	84.44	62.44	+2.00	64.35	+ .09	106.5	109.75
19.5% oil and—							
3.50% ammonia	80.43	60.98	− .55	60.39	+ .04	104.0	103.0
3.75% ammonia	82.11	61.85	+ .26	62.00	+ .11	105.5	105.75
4.00% ammonia	83.70	62.73	+ .97	63.61	+ .09	107.0	108.5
4.25% ammonia	85.29	63.61	+1.28	65.23	+ .06	108.5	111.25
20% oil and—							
3.50% ammonia	81.33	62.15	− .82	61.27	+ .06	106.0	104.5
3.75% ammonia	83.01	63.03	− .02	62.88	+ .13	107.5	107.25
4.00% ammonia	84.60	63.91	+ .71	64.49	+ .11	109.0	110.0
4.25% ammonia	86.19	64.79	+1.40	66.11	+ .08	110.5	112.75
20.5% oil and—							
3.50% ammonia	82.23	63.32	−1.09	62.15	+ .08	108.0	106.0
3.75% ammonia	83.91	64.20	− .29	63.76	+ .15	109.5	108.75
4.00% ammonia	85.50	65.08	+ .42	65.37	+ .13	111.0	111.5
4.25% ammonia	87.09	65.96	+1.13	66.98	+ .11	112.5	114.25
21% oil and—							
3.50% ammonia	83.13	64.49	−1.36	63.06	+ .10	110.0	107.5
3.75% ammonia	84.81	65.37	− .56	64.64	+ .17	111.5	110.25
4.00% ammonia	86.40	66.25	+ .15	66.25	+ .15	113.0	113.0
4.25% ammonia	87.99	67.13	+ .86	67.86	+ .13	114.5	115.75
21.5% oil and—							
3.50% ammonia	84.03	65.71	−1.64	63.91	+ .12	112.0	109.0
3.75% ammonia	85.71	66.55	− .94	65.52	+ .19	113.5	111.75
4.00% ammonia	87.30	67.42	− .12	67.13	+ .17	115.0	114.5
4.25% ammonia	88.89	68.30	+ .59	68.74	+ .15	116.5	117.25

[1] Prices: oil, 10¢/lb.; meal, $90/ton; linters, 4¢/lb.; hulls, $20/ton; seed, $65.39/ton. Basis grade 100: 18.5% oil, 3.50% ammonia. Spread $20. Proposed Quantity Index: (oil × 3) + (ammonia × 9) + 13.

TABLE 4.—*Total value of products obtained from cottonseed of specified composition and at specified prices, the Quantity Index, the proposed Quantity Index, and error when these Quantity Indexes are used* [1]

Content	Total product value	Value present grade	Error	Value proposed grade	Error	Present Quantity Index	Proposed Quantity Index
	$/ton	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*Units*	*Units*
16% oil and—							
3.50% ammonia	74.55	54.50	+0.05	54.50	+0.05	9.0	90.00
3.75% ammonia	75.61	55.40	+ .11	55.48	+ .13	91.5	91.62
4.00% ammonia	76.55	56.31	+ .24	56.46	+ .09	93.0	93.25
4.25% ammonia	77.49	57.22	+ .27	57.45	+ .04	94.5	94.87
16.5% oil and—							
3.50% ammonia	75.75	55.71	+ .04	55.71	+ .04	92.0	92.0
3.75% ammonia	76.81	56.61	+ .20	56.69	+ .12	93.5	93.62
4.00% ammonia	77.75	57.52	+ .23	57.67	+ .08	95.0	95.25
4.25% ammonia	78.69	58.43	+ .26	58.66	+ .03	96.5	96.87
17% oil and—							
3.50% ammonia	76.95	56.92	+ .03	56.92	+ .03	94.0	94.0
3.75% ammonia	78.01	57.83	+ .18	57.90	+ .11	95.5	95.62
4.00% ammonia	78.95	58.73	+ .22	58.85	+ .10	97.0	97.25
4.25% ammonia	79.89	59.64	+ .25	59.87	+ .02	98.5	98.87
17.5% oil and—							
3.50% ammonia	78.15	58.13	+ .02	58.13	+ .02	96.0	96.0
3.75% ammonia	79.21	59.04	+ .17	59.11	+ .10	97.5	97.62
4.00% ammonia	80.15	59.94	+ .21	60.10	+ .05	99.0	99.25
4.25% ammonia	81.09	60.85	+ .24	61.09	0	101.5	100.87
18% oil and—							
3.50% ammonia	79.31	59.34	+ .01	59.34	+ .01	98.0	98.0
3.75% ammonia	80.41	60.25	+ .16	60.32	+ .09	99.5	99.62
4.00% ammonia	81.35	61.16	+ .19	61.31	+ .04	101.0	101.25
4.25% ammonia	82.29	62.06	+ .23	62.29	0	102.5	101.87
18.5% oil and—							
3.50% ammonia	80.55	60.55	0	60.55	0	100.0	100.0
3.75% ammonia	81.61	61.46	+ .15	61.53	+ .08	101.5	101.62
4.00% ammonia	82.55	62.37	+ .18	62.52	+ .03	103.0	103.25
4.25% ammonia	83.49	63.27	+ .22	63.50	+ .01	104.5	104.87
19% oil and—							
3.50% ammonia	81.75	61.76	−0.01	61.76	−0.01	102.0	101.75
3.75% ammonia	82.81	62.67	+ .14	62.75	+ .06	103.5	104.12
4.00% ammonia	83.75	63.58	+ .17	63.73	+ .02	105.0	106.5
4.25% ammonia	84.74	64.49	+ .25	64.71	+ .03	106.5	108.87
19.5% oil and—							
3.50% ammonia	82.95	62.97	− .02	62.97	− .02	104.0	104.0
3.75% ammonia	84.01	63.88	+ .13	63.95	+ .06	105.5	106.62
4.00% ammonia	84.95	64.79	+ .16	64.93	+ .02	107.0	107.25
4.25% ammonia	85.89	65.70	+ .19	65.92	− .03	108.5	108.87
20% oil and—							
3.50% ammonia	84.15	64.18	− .03	64.18	− .03	106.0	106.0
3.75% ammonia	85.21	65.09	+ .12	65.16	+ .05	107.5	107.62
4.00% ammonia	86.15	66.00	+ .15	66.15	0	109.0	109.25
4.25% ammonia	87.09	66.91	+ .18	67.13	− .04	110.5	110.87

See footnote at end of table.

TABLE 4.—*Total value of products obtained from cottonseed of specified composition and at specified prices, the Quantity Index, the proposed Quantity Index, and error when these Quantity Indexes are used* [1]—Continued

Content	Total product value	Value present grade	Error	Value proposed grade	Error	Present Quantity Index	Proposed Quantity Index
	$/ton	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*Units*	*Units*
20.5% oil and—							
3.50% ammonia	85.35	65.39	− .04	65.39	− .04	108.0	108.0
3.75% ammonia	86.41	66.30	+ .11	66.37	+ .04	109.5	109.62
4.00% ammonia	87.35	67.21	+ .14	67.36	− .01	111.0	111.25
4.25% ammonia	88.29	68.12	+ .17	68.34	− .05	112.5	112.81
21% oil and—							
3.50% ammonia	86.55	66.60	− .05	66.60	− .05	110.0	110.0
3.75% ammonia	87.61	69.63	− .02	67.58	+ .03	111.5	111.62
4.00% ammonia	88.55	68.42	+ .13	68.57	− .02	113.0	113.25
4.25% ammonia	89.49	69.33	+ .16	69.55	− .06	114.5	114.87
21.5% oil and—							
3.50% ammonia	87.75	67.81	− .06	67.81	− .06	112.0	112.0
3.75% ammonia	88.81	68.72	+ .09	68.80	+ .01	113.5	113.62
4.00% ammonia	89.70	69.63	+ .07	69.78	− .08	115.0	115.25
4.25% ammonia	90.69	70.54	+ .15	70.76	− .07	116.5	116.87

[1] Prices: oil, 13¢/lb.; meal, $80/ton; linters, 4¢/lb.; hulls, $20/ton; seed, $60.55/ton. Basis grade 100: 18.5% oil, 3.50% ammonia. Spread $20. Proposed Quantity Index: (oil × 4) + (ammonia × 6.5) + 3.25.

TABLE 5.—*Total value of products obtained from cottonseed of specified composition and at specified prices, the Quantity Index, the proposed Quantity Index, and error when these Quantity Indexes are used* [1]

Content	Total product value	Value present grade	Error	Value proposed grade	Error	Present Quantity Index	Proposed Quantity Index
	$/ton	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*Units*	*Units*
16% oil and—							
3.50% ammonia	89.37	71.43	−2.06	69.44	−0.07	90.0	87.50
3.75% ammonia	89.76	72.62	−2.86	69.64	+ .12	91.5	87.75
4.00% ammonia	89.95	73.81	−3.86	69.84	+ .14	93.0	88.0
4.25% ammonia	90.14	75.00	−4.86	70.04	+ .10	94.5	88.25
16.5% oil and—							
3.50% ammonia	91.37	73.02	−1.59	71.43	− .06	92.0	90.0
3.75% ammonia	91.76	74.01	−2.25	71.63	+ .13	93.5	90.25
4.00% ammonia	91.95	75.40	−3.45	71.82	+ .13	95.0	90.5
4.25% ammonia	92.14	76.59	−4.45	72.02	+ .12	96.5	90.75
17% oil and—							
3.50% ammonia	93.37	74.61	−1.24	73.41	− .04	94.0	92.5
3.75% ammonia	93.76	75.80	−2.04	73.61	+ .15	95.5	92.75
4.00% ammonia	93.95	76.99	−3.04	73.81	+ .14	97.0	93.0
4.25% ammonia	94.14	78.18	−4.04	74.01	+ .13	98.5	93.25

See footnote at end of table.

TABLE 5.—*Total value of products obtained from cottonseed of specified composition and at specified prices, the Quantity Index, the proposed Quantity Index, and error when these Quantity Indexes are used* [1]—Continued

Content	Total product value	Value present grade	Error	Value proposed grade	Error	Present Quantity Index	Proposed Quantity Index
	$/ton	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*Units*	*Units*
17.5% oil and—							
3.50% ammonia	95.37	76.20	− .83	75.40	− .03	96.0	95.0
3.75% ammonia	95.76	77.39	−1.63	75.59	+ .17	97.5	95.25
4.00% ammonia	95.95	78.58	−2.63	75.79	− .21	99.0	95.50
4.25% ammonia	96.14	79.99	−3.85	75.99	+ .15	100.5	95.75
18% oil and—							
3.50% ammonia	97.37	77.99	− .62	77.38	− .01	98.0	97.5
3.75% ammonia	97.76	78.97	−1.21	77.58	+ .18	99.5	97.75
4.00% ammonia	97.95	80.16	−2.21	77.78	+ .17	101.0	98.0
4.25% ammonia	98.14	81.35	−3.21	77.98	+ .16	102.5	98.25
18.5% oil and—							
3.50% ammonia	99.37	79.37	0	79.37	0	100.0	100.0
3.75% ammonia	99.76	80.56	− .80	79.56	+ .20	101.5	100.25
4.00% ammonia	99.95	81.75	−1.80	79.76	+ .19	103.0	100.15
4.25% ammonia	100.14	82.94	−2.70	79.96	+ .18	104.5	100.75
19% oil and—							
3.50% ammonia	101.37	80.96	+0.41	81.35	+0.02	102.0	102.50
3.75% ammonia	101.76	82.15	+ .39	81.55	+ .21	103.5	102.75
4.00% ammonia	101.95	83.34	−1.39	81.75	+ .20	105.0	103.0
4.25% ammonia	102.19	84.53	−2.34	81.94	+ .23	106.5	103.25
19.5% oil and—							
3.50% ammonia	103.37	82.54	+ .83	83.34	+ .03	104.0	105.0
3.75% ammonia	103.76	83.74	+ .02	83.54	+ .22	105.5	105.25
4.00% ammonia	103.95	84.93	− .98	83.74	+ .21	107.0	105.5
4.25% ammonia	104.14	86.11	−1.87	83.94	+ .20	108.5	105.75
20% oil and—							
3.50% ammonia	105.37	84.13	+1.24	85.32	+ .05	106.0	107.5
3.75% ammonia	105.76	85.32	+ .44	85.52	+ .24	107.5	107.75
4.00% ammonia	106.95	86.57	− .44	85.72	+ .23	109.0	108.0
4.25% ammonia	106.14	87.70	−1.56	85.92	+ .22	110.5	108.25
20.5% oil and—							
3.50% ammonia	107.37	85.72	+1.85	87.31	+ .06	108.0	110.0
3.75% ammonia	107.76	86.91	+ .85	87.51	+ .25	109.5	110.25
4.00% ammonia	107.95	88.10	− .15	87.70	+ .25	111.0	110.5
4.25% ammonia	108.14	89.29	−1.15	87.90	+ .24	112.5	110.75
21% oil and—							
3.50% ammonia	109.37	87.31	+2.06	89.29	+ .08	110.0	112.5
3.75% ammonia	109.76	88.50	+1.26	89.49	+ .27	111.5	112.75
4.00% ammonia	109.95	89.69	+ .26	89.69	+ .26	113.0	113.0
4.25% ammonia	110.14	90.88	− .74	89.89	+ .25	114.5	113.25
21.5% oil and—							
3.50% ammonia	111.37	88.90	+2.47	91.27	+ .10	112.0	115.0
3.75% ammonia	111.76	90.08	+1.68	91.47	+ .29	113.5	115.25
4.00% ammonia	111.95	91.27	+ .68	91.67	+ .23	115.0	115.5
4.25% ammonia	112.14	92.47	− .33	91.87	+ .27	116.5	115.75

[1] Prices: oil, 21¢/lb.; meal, $40/ton; linters, 4¢/lb.; hulls, $20/ton; seed, $79.37/ton. Basis grade 100: 18.5% oil, 3.50% ammonia. Spread $20. Proposed Quantity Index: (oil × 5) + (ammonia × 1) + 4.

TABLE 6.—*Total value of products obtained from cottonseed of specified composition and at specified prices, the Quantity Index, the proposed Quantity Index, and error when these Quantity Indexes are used* [1]

Content	Total product value	Value present grade	Error	Value proposed grade	Error	Present Quantity Index	Proposed Quantity Index
	$/ton	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*Units*	*Units*
16% oil and—							
3.50% ammonia	88.95	69.71	−0.76	68.74	+0.21	90.0	88.75
3.75% ammonia	89.96	70.87	− .91	69.60	+ .36	91.5	89.875
4.00% ammonia	90.80	72.03	−1.23	70.48	+ .32	93.0	91.0
4.25% ammonia	91.64	73.19	−1.55	71.35	+ .19	94.5	92.12
16.5% oil and—							
3.50% ammonia	90.65	71.25	− .60	70.49	+ .17	92.0	91.0
3.75% ammonia	91.66	92.42	− .76	71.35	+ .31	93.5	92.12
4.00% ammonia	92.50	73.58	−1.08	72.22	+ .28	95.0	93.25
4.25% ammonia	93.34	74.74	−1.40	73.09	+ .25	96.5	94.37
17% oil and—							
3.50% ammonia	92.35	72.80	− .45	72.22	+ .13	94.0	93.25
3.75% ammonia	93.36	73.96	− .60	73.09	+ .27	95.5	94.37
4.00% ammonia	94.20	75.13	− .93	73.96	+ .24	97.0	95.5
4.25% ammonia	95.04	76.29	−1.25	74.83	+ .21	98.5	96.12
17.5% oil and—							
3.50% ammonia	94.05	74.35	− .30	73.96	+ .11	96.0	95.5
3.75% ammonia	95.06	75.51	− .45	74.83	+ .23	97.5	96.62
4.00% ammonia	95.90	76.68	− .78	75.70	+ .20	99.0	97.75
4.25% ammonia	96.74	77.84	−1.10	76.57	+ .17	100.5	98.87
18% oil and—							
3.50% ammonia	95.75	75.90	− .15	75.70	+ .05	98.0	97.75
3.75% ammonia	96.76	77.06	− .30	76.57	+ .19	99.5	98.87
4.00% ammonia	97.60	78.22	− .62	77.45	+ .15	101.0	100.0
4.25% ammonia	98.44	79.39	− .85	78.32	+ .12	102.5	101.12
18.5% oil and—							
3.50% ammonia	97.45	77.45	0	77.45	0	100.0	100.0
3.75% ammonia	98.46	78.61	− .15	78.32	+ .14	101.5	101.12
4.00% ammonia	99.30	79.77	− .37	79.19	+ .11	103.0	102.25
4.25% ammonia	100.14	80.93	− .79	80.06	+ .08	104.5	103.37
19% oil and—							
3.50% ammonia	99.15	79.00	+0.15	79.19	−0.04	102.0	102.25
3.75% ammonia	100.16	80.16	0	80.06	+ .10	103.5	103.37
4.00% ammonia	101.00	81.32	− .32	80.93	+ .07	105.0	104.5
4.25% ammonia	101.89	82.48	− .59	81.80	+ .09	106.5	105.62
19.5% oil and—							
3.50% ammonia	100.85	80.55	+ .30	80.93	− .08	104.0	104.5
3.75% ammonia	101.86	81.71	+ .15	81.80	+ .06	105.5	105.62
4.00% ammonia	102.70	82.87	− .17	82.67	+ .03	107.0	106.75
4.25% ammonia	103.54	84.03	− .49	83.54	0	108.5	107.87
20% oil and—							
3.50% ammonia	102.55	82.10	+ .45	82.67	− .12	106.0	106.75
3.75% ammonia	103.56	83.26	+ .30	83.54	+ .02	107.5	107.87
4.00% ammonia	104.40	84.42	− .02	84.42	− .02	109.0	109.0
4.25% ammonia	105.34	85.58	− .24	85.29	+ .05	110.5	110.12

See footnote at end of table.

TABLE 6.—*Total value of products obtained from cottonseed of specified composition and at specified prices, the Quantity Index, the proposed Quantity Index, and error when these Quantity Indexes are used* [1]—Continued

Content	Total product value	Value present grade	Error	Value proposed grade	Error	Present Quantity Index	Proposed Quantity Index
	$/ton	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*Units*	*Units*
20.5% oil and—							
3.50% ammonia	104.25	83.65	+ .60	84.42	− .17	108.0	109.0
3.75% ammonia	105.26	84.81	+ .45	85.29	− .03	109.5	110.12
4.00% ammonia	106.10	85.97	+ .13	86.16	− .06	111.0	111.25
4.25% ammonia	106.94	87.13	− .19	87.03	− .09	112.5	112.37
21% oil and—							
3.50% ammonia	105.95	85.20	+ .75	86.16	− .21	110.0	111.25
3.75% ammonia	106.96	86.36	+ .60	87.03	− .07	111.5	112.37
4.00% ammonia	107.80	87.52	+ .28	87.90	− .10	113.0	113.50
4.25% ammonia	108.64	88.68	− .04	88.77	− .13	114.5	114.62
21.5% oil and—							
3.50% ammonia	107.65	86.74	+ .91	87.90	− .25	112.0	113.5
3.75% ammonia	108.66	87.91	+ .75	88.77	− .11	113.5	114.62
4.00% ammonia	109.50	89.07	+ .43	89.64	− .14	115.0	115.75
4.25% ammonia	110.34	90.23	+ .11	90.51	− .17	116.5	116.87

[1] Prices: oil, 18¢/lb.; meal, $60/ton; linters, 4¢/lb.; hulls, $20/ton; seed, $77.45/ton. Basis grade 100: 18.5% oil, 3.50% ammonia. Spread $20. Proposed Quantity Index: (oil × 4.5) + (ammonia × 4.5) + 1.

TABLE 7.—*Total value of products obtained from cottonseed of specified composition and at specified prices, the Quantity Index, the proposed Quantity Index, and error when these Quantity Indexes are used* [1]

Content	Total product value	Value present grade	Error	Value proposed grade	Error	Present Quantity Index	Proposed Quantity Index
	$/ton	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*Units*	*Units*
16% oil and—							
3.50% ammonia	79.89	58.85	+1.04	59.67	+0.22	90.0	91.25
3.75% ammonia	81.55	59.83	+1.72	61.22	+ .33	91.5	93.62
4.00% ammonia	83.10	60.81	+2.29	62.77	+ .33	93.0	96.0
4.25% ammonia	84.65	61.79	+2.86	64.33	+ .32	94.5	98.37
16.5% oil and—							
3.50% ammonia	80.99	60.16	+ .83	60.81	+ .18	92.0	93.0
3.75% ammonia	82.65	61.14	+1.51	62.36	+ .29	93.5	95.37
4.00% ammonia	84.20	62.12	+2.08	63.92	+ .28	95.0	97.75
4.25% ammonia	85.75	63.10	+2.65	65.49	+ .28	96.5	101.12
17% oil and—							
3.50% ammonia	82.09	61.47	+ .62	61.96	+ .13	94.0	94.75
3.75% ammonia	83.75	62.45	+1.30	63.51	+ .14	95.5	97.12
4.00% ammonia	85.30	63.43	+1.87	65.06	+ .24	97.0	99.5
4.25% ammonia	86.85	64.41	+2.44	66.62	+ .23	98.5	101.87

See footnote at end of table.

TABLE 7.—*Total value of products obtained from cottonseed of specified composition and at specified prices, the Quantity Index, the proposed Quantity Index, and error when these Quantity Indexes are used* [1]—Continued

Content	Total product value	Value present grade	Error	Value proposed grade	Error	Present Quantity Index	Proposed Quantity Index
	$/ton	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*Units*	*Units*
17.5% oil and—							
3.50% ammonia	83.19	62.77	+ .42	63.10	+ .09	96.0	96.5
3.75% ammonia	84.85	63.76	+1.09	64.65	+ .20	97.5	98.87
4.00% ammonia	86.40	64.74	+1.66	66.21	+ .19	99.0	101.25
4.25% ammonia	87.95	65.72	+2.23	67.76	+ .19	100.5	103.62
18% oil and—							
3.50% ammonia	84.29	64.08	+ .21	64.24	+ .05	98.0	98.25
3.75% ammonia	85.95	65.06	+ .84	65.80	+ .15	99.5	100.62
4.00% ammonia	87.50	66.04	+1.46	67.35	+ .15	101.0	103.0
4.25% ammonia	89.05	67.02	+2.03	68.90	+ .15	102.5	105.37
18.5% oil and—							
3.50% ammonia	85.39	65.39	0	65.39	0	100.0	100.0
3.75% ammonia	87.05	66.37	+ .68	66.95	+ .10	101.5	102.37
4.00% ammonia	88.60	67.35	+1.82	68.50	+ .10	103.0	104.75
4.25% ammonia	90.15	68.33	+1.82	70.05	+ .10	104.5	107.12
19% oil and—							
3.50% ammonia	86.49	66.70	−0.21	66.53	−0.04	102.0	101.75
3.75% ammonia	88.15	67.68	+ .47	68.09	+ .06	103.5	104.12
4.00% ammonia	89.70	68.66	+1.04	69.64	+ .06	105.0	106.5
4.25% ammonia	91.30	69.64	+1.66	71.19	+ .11	106.5	108.87
19.5% oil and—							
3.50% ammonia	87.59	68.00	− .41	67.51	+ .08	104.0	103.25
3.75% ammonia	89.25	68.99	+ .26	69.23	+ .02	105.5	105.87
4.00% ammonia	90.80	69.97	+ .83	70.78	+ .02	107.0	108.25
4.25% ammonia	92.35	70.95	+1.40	72.33	+ .02	108.5	110.62
20% oil and—							
3.50% ammonia	88.77	69.31	− .54	68.82	− .05	106.0	105.25
3.75% ammonia	90.35	70.29	+ .06	70.53	− .18	107.5	107.62
4.00% ammonia	91.90	71.30	+ .60	72.05	− .15	109.0	110.0
4.25% ammonia	93.45	72.26	+1.19	73.64	− .19	110.5	112.37
20.5% oil and—							
3.50% ammonia	89.79	70.62	− .83	70.13	− .19	108.0	107.0
3.75% ammonia	91.45	71.60	− .15	71.84	− .07	109.5	109.37
4.00% ammonia	93.00	72.58	+ .42	73.40	− .07	111.0	111.75
4.25% ammonia	94.55	73.56	+ .99	74.70	− .08	112.5	114.12
21% oil and—							
3.50% ammonia	90.89	71.93	−1.04	70.78	+ .11	110.0	108.25
3.75% ammonia	92.55	72.91	− .36	72.66	− .11	111.5	111.12
4.00% ammonia	94.10	73.89	+ .21	74.22	− .12	113.0	113.5
4.25% ammonia	95.65	74.87	+ .78	75.77	− .12	114.5	115.87
21.5% oil and—							
3.50% ammonia	91.99	73.24	−1.25	72.26	− .27	112.0	110.5
3.75% ammonia	93.65	74.22	− .57	73.78	− .13	113.5	112.82
4.00% ammonia	95.20	75.20	0	75.36	− .16	115.0	115.25
4.25% ammonia	96.75	76.18	+ .57	76.91	− .16	116.5	117.62

[1] Prices: oil, 12¢/lb.; meal, $80/ton; linters, 4¢/lb.; hulls, $20/ton; seed, $65.39/ton. Basis grade 100: 18.5% oil, 3.50% ammonia. Spread $20. Proposed Quantity Index: (oil × 3.5) + (ammonia × 9.5) + 2.

TABLE 8.—*Total value of products obtained from cottonseed of specified composition and at specified prices, the Quantity Index, the proposed Quantity Index, and error when these Quantity Indexes are used* [1]

Content	Total product value	Value present grade	Error	Value proposed grade	Error	Present Quantity Index	Proposed Quantity Index
	$/ton	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*Units*	*Units*
16% oil and—							
3.50% ammonia	68.78	47.95	+0.83	48.62	+0.16	90.0	91.25
3.75% ammonia	70.04	48.75	+1.29	49.82	+ .22	91.5	93.50
4.00% ammonia	71.22	49.55	+1.67	51.02	+ .20	93.0	95.75
4.25% ammonia	72.70	52.35	+2.35	52.21	+ .49	94.5	98.0
16.5% oil and—							
3.50% ammonia	69.68	49.02	+ .66	49.55	+ .13	92.0	93.10
3.75% ammonia	70.94	49.82	+1.12	50.75	+ .19	93.5	95.25
4.00% ammonia	72.12	50.62	+1.50	51.95	+ .17	95.0	97.50
4.25% ammonia	73.60	51.41	+2.20	53.15	+ .45	96.5	99.75
17% oil and—							
3.50% ammonia	70.53	50.08	+ .45	50.48	+ .05	94.0	94.75
3.75% ammonia	71.84	50.08	+ .96	51.68	+ .16	95.5	97.0
4.00% ammonia	73.02	51.68	+1.34	52.88	+ .14	97.0	99.25
4.25% ammonia	74.50	52.48	+2.02	54.08	+ .42	98.5	101.50
17.5% oil and—							
3.50% ammonia	71.48	51.15	+ .33	51.42	+ .06	96.0	96.50
3.75% ammonia	72.47	51.95	+ .79	52.61	+ .13	97.5	98.75
4.00% ammonia	73.92	52.75	+1.17	53.81	− .11	99.0	101.0
4.25% ammonia	75.40	53.55	+1.85	55.01	− .49	100.5	103.25
18% oil and—							
3.50% ammonia	72.38	52.21	+ .17	52.35	− .03	98.0	98.25
3.75% ammonia	73.64	53.01	+ .63	53.55	− .09	99.5	100.50
4.00% ammonia	74.82	53.81	+1.01	54.75	− .07	101.0	102.75
4.25% ammonia	76.30	54.61	+1.69	55.94	− .36	102.5	105.0
18.5% oil and—							
3.50% ammonia	73.28	53.28	+0	53.28	0	100.0	100.0
3.75% ammonia	74.54	54.08	− .46	54.48	− .06	101.5	102.25
4.00% ammonia	75.72	54.68	− .84	55.68	− .04	103.0	104.50
4.25% ammonia	77.20	55.63	−1.52	56.98	− .22	104.5	106.75
19% oil and—							
3.50% ammonia	74.18	54.35	−0.17	54.21	−0.03	102.0	101.75
3.75% ammonia	75.44	55.14	+ .30	55.41	+ .03	103.5	104.0
4.00% ammonia	76.62	55.94	+ .68	56.61	− .06	105.0	106.25
4.25% ammonia	78.15	56.74	+1.41	57.81	+ .34	106.5	108.5
19.5% oil and—							
3.50% ammonia	75.08	55.41	− .33	55.14	− .06	104.0	103.5
3.75% ammonia	76.34	56.21	.13	56.21	+ .13	105.5	105.75
4.00% ammonia	77.52	57.01	−1.51	57.54	− .02	107.0	108.0
4.25% ammonia	79.00	57.81	1.19	58.74	− .14	108.5	110.25
20% oil and—							
3.50% ammonia	75.98	56.48	− .50	56.08	− .10	106.0	105.25
3.75% ammonia	77.24	57.28	− .04	57.28	− .04	107.5	107.5
4.00% ammonia	78.42	58.07	.35	58.47	− .05	109.0	109.75
4.25% ammonia	79.90	58.87	1.03	59.67	+ .23	110.5	112.0

See footnote at end of table.

TABLE 8.—*Total value of products obtained from cottonseed of specified composition and at specified prices, the Quantity Index, the proposed Quantity Index, and error when these Quantity Indexes are used* [1]—Continued

Content	Total product value	Value present grade	Error	Value proposed grade	Error	Present Quantity Index	Proposed Quantity Index
	$/ton	*$/ton*	*$/ton*	*$/ton*	*$/ton*	*Units*	*Units*
20.5% oil and—							
3.50% ammonia	76.88	57.54	− .66	59.01	− .23	108.0	107.0
3.75% ammonia	78.14	58.34	− .20	58.21	− .07	109.5	109.25
4.00% ammonia	79.32	59.14	− .18	59.41	− .09	111.0	111.5
4.25% ammonia	80.80	59.94	.26	60.60	+ .20	112.5	113.75
21% oil and—							
3.50% ammonia	77.78	58.61	− .83	57.94	− .16	110.0	108.75
3.75% ammonia	79.04	59.41	− .37	59.14	− .10	111.5	110.0
4.00% ammonia	80.22	60.20	+ .02	60.34	− .12	113.0	113.25
4.25% ammonia	81.70	61.27	+ .43	61.54	+ .16	114.5	115.5
21.5% oil and—							
3.50% ammonia	78.68	59.67	− .99	58.37	− .19	112.0	110.5
3.75% ammonia	77.94	60.47	− .53	60.07	− .13	113.5	112.75
4.00% ammonia	81.12	61.27	− .15	61.27	− .15	115.0	115.0
4.25% ammonia	82.60	62.07	+ .53	62.47	+ .13	116.5	117.25

[1] Prices: oil, 10¢/lb.; meal, $66/ton; linters, 4¢/lb.; hulls, $20/ton; seed, $53.28/ton. Basis grade 100: 18.5% oil, 3.50% ammonia. Spread $20. Proposed Quantity Index: (oil × 3.5) + (ammonia × 9) + 3.75.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1971 O—384-851